SUBELEMENT T3

Radio wave characteristics: properties of radio waves; propagation modes

3 Exam Questions - 3 Groups

T3A -

Radio wave characteristics: how a radio signal travels; fading; multipath; wavelength vs. penetration; antenna orientation

Electromagnetic waves carry radio signals between transmitting and receiving stations. VHF frequencies are “line of site”, but tend to bounce around between obstructions such as buildings and antenna towers.

Should another operator report that your stations 2 meter signals were strong just a moment ago, but now they are weak or distorted, **try moving a few feet, as random reflections may be causing multi-path distortion.**

T3A01

What should you do if another operator reports that your station’s 2 meter signals were strong just a moment ago, but now they are weak or distorted?

A. Change the batteries in your radio to a different type

B. Turn on the CTCSS tone

C. Ask the other operator to adjust his squelch control

D. Try moving a few feet or changing the direction of your antenna if possible, as reflections may be causing multi-path distortion

T3A01

What should you do if another operator reports that your station's 2 meter signals were strong just a moment ago, but now they are weak or distorted?

D. Try moving a few feet or changing the direction of your antenna if possible, as reflections may be causing multi-path distortion

T3A07

What type of wave carries radio signals between transmitting and receiving stations?

A. Electromagnetic
B. Electrostatic
C. Surface acoustic
D. Magnetostrictive

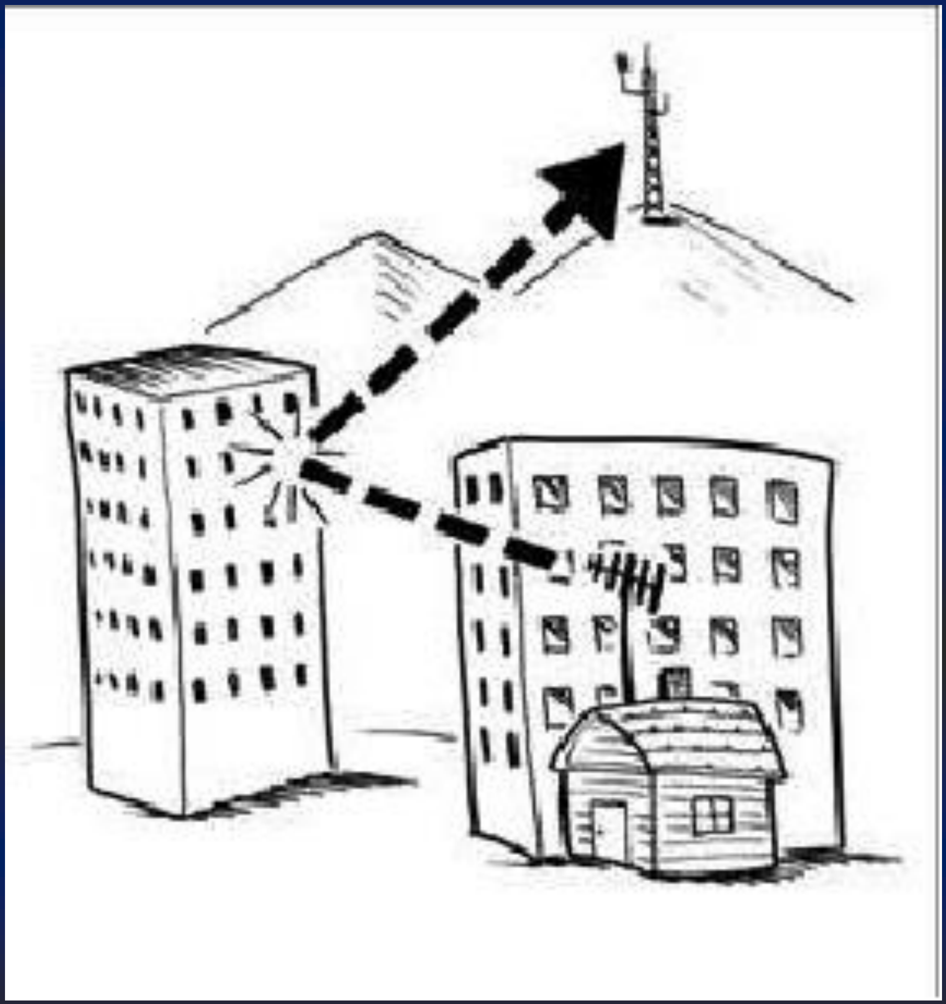
T3A07

What type of wave carries radio signals between transmitting and receiving stations?

A. Electromagnetic

When using a directional antenna, your station might be able to access a distant repeater if buildings or other obstructions are blocking the direct line of sight path.

Do so by trying to find a path that reflects signals to the repeater.



The idea is to find a structure that will reflect you signal towards the distant repeater instead of in some other direction.

Picket fencing is the term commonly used to describe the rapid fluttering sound sometimes heard from mobile stations that are moving while transmitting. Again, reflections are the culprit.

Many hams take their hand held radios to work with them so they can listen in on activity during the day.

Do this at your own risk. Not all companies approve. Or you may take your radio to the shopping mall.

You should be aware that UHF signals are often more effective from inside buildings than VHF signals as the shorter wavelength allows them to more easily penetrate the structure of buildings.

T3A05

When using a directional antenna, how might your station be able to access a distant repeater if buildings or obstructions are blocking the direct line of sight path?

A. Change from vertical to horizontal polarization

B. Try to find a path that reflects signals to the repeater

C. Try the long path

D. Increase the antenna SWR

T3A05

When using a directional antenna, how might your station be able to access a distant repeater if buildings or obstructions are blocking the direct line of sight path?

B. Try to find a path that reflects signals to the repeater

T3A06

What term is commonly used to describe the rapid fluttering sound sometimes heard from mobile stations that are moving while transmitting?

A. Flip-flopping

B. Picket fencing

C. Frequency shifting

D. Pulsing

T3A06

What term is commonly used to describe the rapid fluttering sound sometimes heard from mobile stations that are moving while transmitting?

B. Picket fencing

T3A02

Why are UHF signals often more effective from inside buildings than VHF signals?

A. VHF signals lose power faster over distance

B. The shorter wavelength allows them to more easily penetrate the structure of buildings

C. This is incorrect; VHF works better than UHF inside buildings

D. UHF antennas are more efficient than VHF antennas

T3A02

Why are UHF signals often more effective from inside buildings than VHF signals?

B. The shorter wavelength allows them to more easily penetrate the structure of buildings

Signals could be significantly weaker if the antennas at opposite ends of a `VHF or UHF line of sight radio link are not using the same polarization.

In ham radio, when we talk about polarization, we usually mean whether the antenna is vertical in relationship to the ground or horizontal in relationship to the ground.

Since Mobile operation is common on the 2 meter and 70 cm bands, all repeaters, base stations, and mobiles use vertically polarized antennas.

Horizontal antenna polarization is normally used for long-distance weak-signal CW and SSB contacts using the VHF and UHF bands.

T3A03

What antenna polarization is normally used for long-distance weak-signal CW and SSB contacts using the VHF and UHF bands?

A. Right-hand circular

B. Left-hand circular

C. Horizontal

D. Vertical

T3A03

What antenna polarization is normally used for long-distance weak-signal CW and SSB contacts using the VHF and UHF bands?

C. Horizontal

T3A04

What can happen if the antennas at opposite ends of a VHF or UHF line of sight radio link are not using the same polarization?

A. The modulation sidebands might become inverted

B. Signals could be significantly weaker

C. Signals have an echo effect on voices

D. Nothing significant will happen

T3A04

What can happen if the antennas at opposite ends of a VHF or UHF line of sight radio link are not using the same polarization?

B. Signals could be significantly weaker

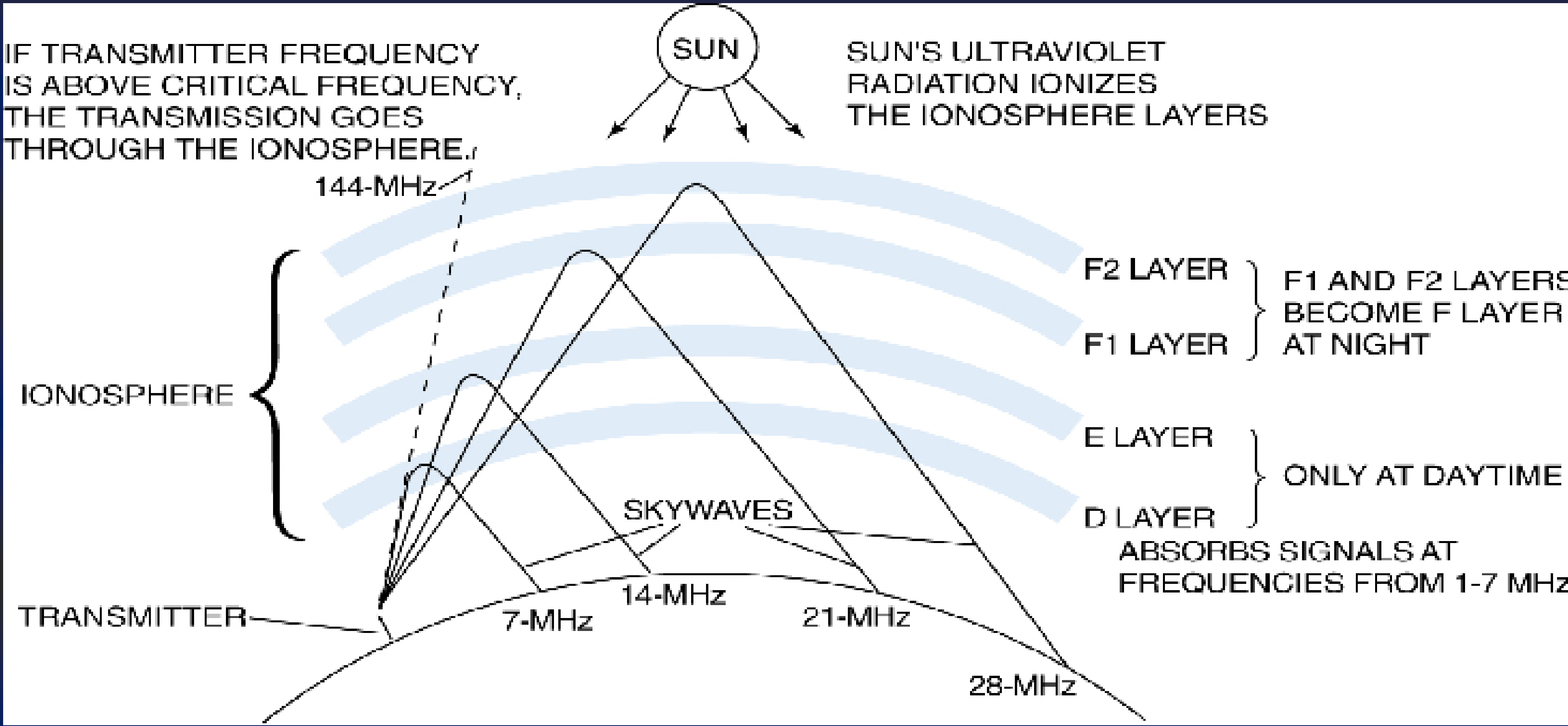
The ionosphere is the part of the atmosphere that enables the propagation of radio signals around the world.

Under certain conditions signals bounce off the ionosphere. This reflection is often called “skip”.

The cause of irregular fading of signals from distant stations during times of generally good reception is due to random combining of signals arriving via different paths.

Due to this irregular fading, **error rates are likely to increase** on VHF or UHF data signals propagated over multiple paths.

Skip signals refracted from the ionosphere are elliptically polarized and either vertically or horizontally polarized antennas may be used for transmission or reception.



IF TRANSMITTER FREQUENCY IS ABOVE CRITICAL FREQUENCY, THE TRANSMISSION GOES THROUGH THE IONOSPHERE.
SUN
SUN'S ULTRAVIOLET RADIATION IONIZES THE IONOSPHERE LAYERS
144-MHz
IONOSPHERE
F2 LAYER
F1 LAYER
F1 AND F2 LAYERS BECOME F LAYER AT NIGHT
E LAYER
D LAYER
ONLY AT DAYTIME
SKYWAVES
ABSORBS SIGNALS AT FREQUENCIES FROM 1-7 MHz
TRANSMITTER
7-MHz
14-MHz
21-MHz
28-MHz

During skip conditions, two stations having the same antenna polarization becomes less important because the resultant signals can be either vertical, horizontal, or mixture of both.

T3A08

Which of the following is a likely cause of irregular fading of signals received by ionospheric reflection?

A. Frequency shift due to Faraday rotation
B. Interference from thunderstorms
C. Random combining of signals arriving via different paths
D. Intermodulation distortion

T3A08

Which of the following is a likely cause of irregular fading of signals received by ionospheric reflection?

C. Random combining of signals arriving via different paths

T3A09

Which of the following results from the fact that skip signals refracted from the ionosphere are elliptically polarized?

A. Digital modes are unusable

B. Either vertically or horizontally polarized antennas may be used for transmission or reception

C. FM voice is unusable

D. Both the transmitting and receiving antennas must be of the same polarization

T3A09

Which of the following results from the fact that skip signals refracted from the ionosphere are elliptically polarized?

B. Either vertically or horizontally polarized antennas may be used for transmission or reception

T3A10

What may occur if data signals propagate over multiple paths?

A. Transmission rates can be increased by a factor equal to the number of separate paths observed

B. Transmission rates must be decreased by a factor equal to the number of separate paths observed

C. No significant changes will occur if the signals are transmitting using FM

D. Error rates are likely to increase

T3A10

What may occur if data signals propagate over multiple paths?

D. Error rates are likely to increase

T3A11

Which part of the atmosphere enables the propagation of radio signals around the world?

A. The stratosphere
B. The troposphere
C. The ionosphere
D. The magnetosphere

T3A11

Which part of the atmosphere enables the propagation of radio signals around the world?

C. The ionosphere

T3B –

Radio and electromagnetic wave properties: the electromagnetic spectrum; wavelength vs. frequency; velocity of electromagnetic waves; calculating wavelength

The two components of a radio wave are the electric and magnetic fields. The orientation of the electric field determines the radio waves polarization.

Radio waves travel through free space at the speed of light.

Another way to say it is the approximate velocity of a radio wave as it travels through free space is 300,000,000 meters per second.

That is so fast that it is almost instantaneously received at any point in the world from the time it is transmitted.

Even when bouncing a signal off the moon, which amazingly, is common practice on the ham bands, the radio wave is back to earth in about 3 seconds!

The name for the distance a radio wave travels during one complete cycle is wavelength.

The term that describes the number of times per second that an alternating current reverses direction is frequency.

Take our 146.520 MHz simplex frequency. It completes 146,520,000 cycles per second.

That is the frequency in Hertz. We shorten it to 146.520 Megahertz just to make it easier to say and remember.

The wavelength of a radio wave relates to its frequency inversely, as the wavelength gets shorter the frequency increases.

As you get more experience in the ham radio world, you will take this for granted.

On the shortwave bands, 40 meters is 7.1 MHz and 20 meters is 14.1 MHz. As the frequency goes up, the wavelength in meters goes down.

Another thing you will need to know for the exam is that **Electric and magnetic fields** are the two components of a radio wave.

T3B01

What is the name for the distance a radio wave travels during one complete cycle?

A. Wave speed

B. Waveform

C. Wavelength

D. Wave spread

T3B01

What is the name for the distance a radio wave travels during one complete cycle?

C. Wavelength

T3B04

How fast does a radio wave travel through free space?

A. At the speed of light
B. At the speed of sound
C. Its speed is inversely proportional to its wavelength
D. Its speed increases as the frequency increases

T3B04

How fast does a radio wave travel through free space?

A. At the speed of light

T3B05

How does the wavelength of a radio wave relate to its frequency?

A. The wavelength gets longer as the frequency increases

B. The wavelength gets shorter as the frequency increases

C. There is no relationship between wavelength and frequency

D. The wavelength depends on the bandwidth of the signal

T3B05

How does the wavelength of a radio wave relate to its frequency?

B. The wavelength gets shorter as the frequency increases

T3B02

What property of a radio wave is used to describe its polarization?

A. The orientation of the electric field
B. The orientation of the magnetic field
C. The ratio of the energy in the magnetic field to the energy in the electric field
D. The ratio of the velocity to the wavelength

T3B02

What property of a radio wave is used to describe its polarization?

A. The orientation of the electric field

T3B03

What are the two components of a radio wave?

A. AC and DC

B. Voltage and current

C. Electric and magnetic fields

D. Ionizing and non-ionizing radiation

T3B03

What are the two components of a radio wave?

C. Electric and magnetic fields

T3B11

What is the approximate velocity of a radio wave as it travels through free space?

A. 3000 kilometers per second

B. 300,000,000 meters per second

C. 300,000 miles per hour

D. 186,000 miles per hour

T3B11

What is the approximate velocity of a radio wave as it travels through free space?

B. 300,000,000 meters per second

The formula for converting frequency to wavelength in meters is the wavelength in meters equals 300 divided by frequency in megahertz.

Don’t want to memorize the frequency and band relationships mentioned in T1?

Then just remember this formula. What band is 146.520 MHz located in? 300 / 146.520 = 2.047 meters.

Hey! That is the 2 meter ham band!

What about 52.525 MHz? 300 / 52.525 = 5.712 meters.

Close enough to 6 meters to know that 6 meters would be the correct answer on the test.

The property of radio waves often used to identify the different frequency bands is the approximate wavelength.

Just like the IRS, we like to round off our numbers so 2.047 is rounded down to 2 meters and 5.712 is rounded up to 6 meters.

T3B06

What is the formula for converting frequency to approximate wavelength in meters?

A. Wavelength in meters equals frequency in hertz multiplied by 300

B. Wavelength in meters equals frequency in hertz divided by 300

C. Wavelength in meters equals frequency in megahertz divided by 300

D. Wavelength in meters equals 300 divided by frequency in megahertz

T3B06

What is the formula for converting frequency to approximate wavelength in meters?

D. Wavelength in meters equals 300 divided by frequency in megahertz

You will need to know the frequency limits of the radio spectrum used in ham radio. It is really simple and you need know only three of them.

- The frequency range referred to as HF is **3 MHz to 30 MHz.**
- The frequency limits of the VHF spectrum are **30 MHz to 300 MHz.**
- The frequency limits of the UHF spectrum are **300 MHz to 3000 MHz.**

T3B08

What are the frequency limits of the VHF spectrum?

A. 30 to 300 kHz

B. 30 to 300 MHz

C. 300 to 3000 kHz

D. 300 to 3000 MHz

T3B08

What are the frequency limits of the VHF spectrum?

B. 30 to 300 MHz

T3B09

What are the frequency limits of the UHF spectrum?

A. 30 to 300 kHz

B. 30 to 300 MHz

C. 300 to 3000 kHz

D. 300 to 3000 MHz

T3B09

What are the frequency limits of the UHF spectrum?

D. 300 to 3000 MHz

T3B10

What frequency range is referred to as HF?

A. 300 to 3000 MHz

B. 30 to 300 MHz

C. 3 to 30 MHz

D. 300 to 3000 kHz

T3B10

What frequency range is referred to as HF?

C. 3 to 30 MHz

T3B07

What property of radio waves is often used to identify the different frequency bands?

A. The approximate wavelength

B. The magnetic intensity of waves

C. The time it takes for waves to travel one mile

D. The voltage standing wave ratio of waves

T3B07

What property of radio waves is often used to identify the different frequency bands?

A. The approximate wavelength

T3C –

Propagation modes: line of sight; sporadic E; meteor and auroral scatter and reflections; tropospheric ducting; F layer skip; radio horizon

UHF signals "direct" (not via a repeater) are rarely heard from stations outside your local coverage area because UHF signals are usually not reflected by the ionosphere.

UHF signals are mostly line of sight. That being if there is no obstructions between the path of two stations, they should be able to communicate with each other.

VHF signals, while mostly line of sight, are occasionally reflected by the ionosphere.

When VHF signals are being received from long distances these signals are being refracted from a sporadic E layer.

Sporadic E propagation is most commonly associated with occasional strong over-the-horizon signals on the 10, 6, and 2 meter bands.

From dawn to shortly after sunset during periods of high sunspot activity is generally the best time for long-distance 10 meter band propagation via the F layer.

T3C01

Why are direct (not via a repeater) UHF signals rarely heard from stations outside your local coverage area?

A. They are too weak to go very far

B. FCC regulations prohibit them from going more than 50 miles

C. UHF signals are usually not reflected by the ionosphere

D. They collide with trees and shrubbery and fade out

T3C01

Why are direct (not via a repeater) UHF signals rarely heard from stations outside your local coverage area?

C. UHF signals are usually not reflected by the ionosphere

T3C02

Which of the following might be happening when VHF signals are being received from long distances?

A. Signals are being reflected from outer space

B. Signals are arriving by sub-surface ducting

C. Signals are being reflected by lightning storms in your area

D. Signals are being refracted from a sporadic E layer

T3C02

Which of the following might be happening when VHF signals are being received from long distances?

D. Signals are being refracted from a sporadic E layer

T3C09

What is generally the best time for long-distance 10 meter band propagation via the F layer?

A. From dawn to shortly after sunset during periods of high sunspot activity

B. From shortly after sunset to dawn during periods of high sunspot activity

C. From dawn to shortly after sunset during periods of low sunspot activity

D. From shortly after sunset to dawn during periods of low sunspot activity

T3C09

What is generally the best time for long-distance 10 meter band propagation via the F layer?

A. From dawn to shortly after sunset during periods of high sunspot activity

A characteristic of VHF signals received via auroral reflection is that the signals exhibit rapid fluctuations of strength and often sound distorted.

Heard of the Northern Lights? This is nothing more than an atmospheric condition caused by the sun. It is also called an aurora.

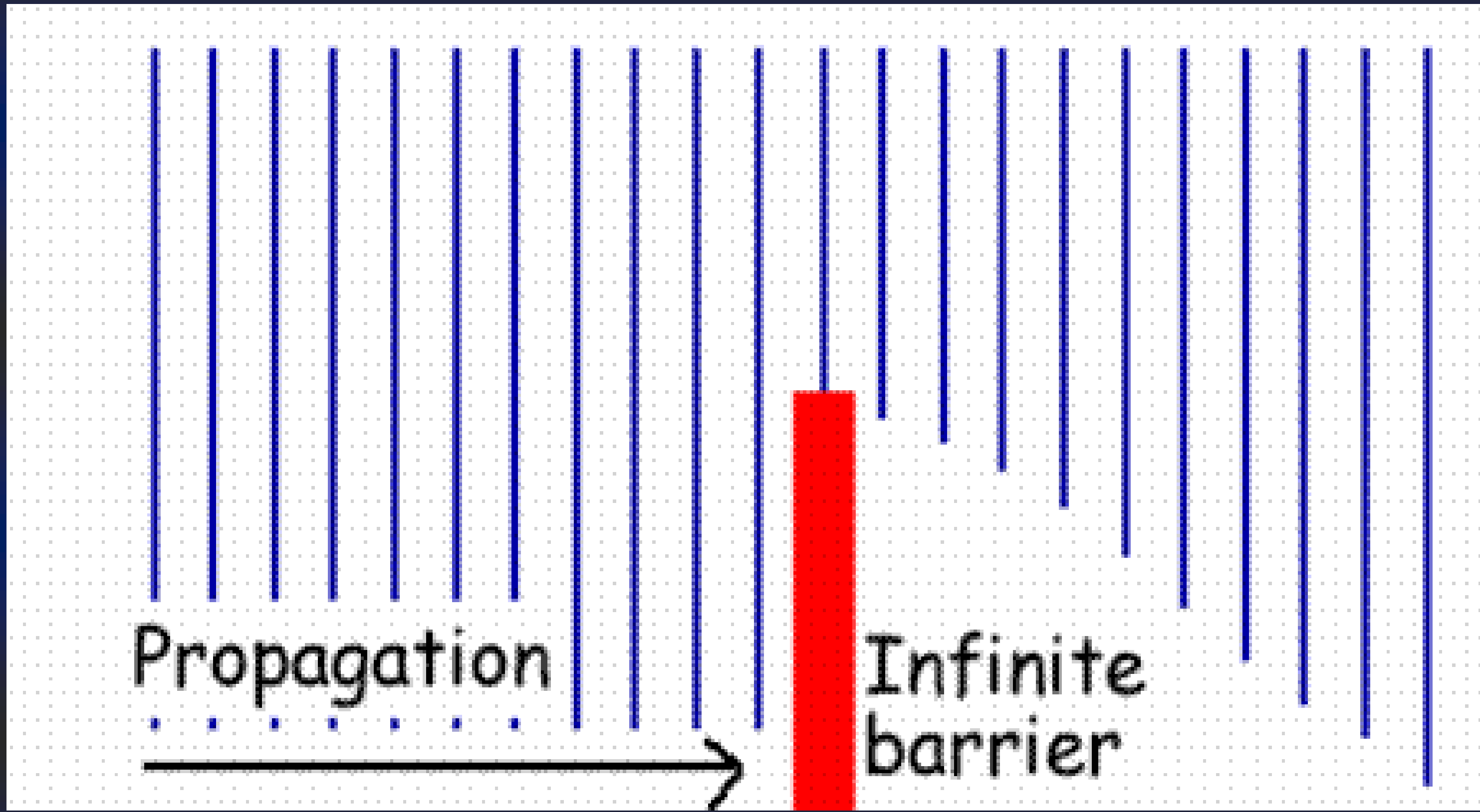
Hams can reflect VHF signals off of an aurora to increase communications distance, however there is a lot of distortion to the reflected signal.

In an odd ham sense, that makes it fun to talk to stations using aurora reflections.

Sporadic E is most commonly associated with occasional strong over-the-horizon signals on the 10, 6, and 2 meter bands.

Tropospheric scatter is responsible for allowing over-the-horizon VHF and UHF communications to ranges of approximately 300 miles on a regular basis.

If you are looking to work DX, then Six or ten meters may provide long distance communications during the peak of the sunspot cycle. These are two really fun bands!



Knife-Edge diffraction refers to signals that are partially refracted around solid objects exhibiting sharp edges. See picture.

T3C03

What is a characteristic of VHF signals received via auroral reflection?

A. Signals from distances of 10,000 or more miles are common

B. The signals exhibit rapid fluctuations of strength and often sound distorted

C. These types of signals occur only during winter nighttime hours

D. These types of signals are generally strongest when your antenna is aimed west

T3C03

What is a characteristic of VHF signals received via auroral reflection?

B. The signals exhibit rapid fluctuations of strength and often sound distorted

T3C04

Which of the following propagation types is most commonly associated with occasional strong over-the-horizon signals on the 10, 6, and 2 meter bands?

A. Backscatter

B. Sporadic E

C. D layer absorption

D. Gray-line propagation

T3C04

Which of the following propagation types is most commonly associated with occasional strong over-the-horizon signals on the 10, 6, and 2 meter bands?

B. Sporadic E

T3C05

Which of the following effects might cause radio signals to be heard despite obstructions between the transmitting and receiving stations?

A. Knife-edge diffraction

B. Faraday rotation

C. Quantum tunneling

D. Doppler shift

T3C05

Which of the following effects might cause radio signals to be heard despite obstructions between the transmitting and receiving stations?

A. Knife-edge diffraction

T3C06

What mode is responsible for allowing over-the-horizon VHF and UHF communications to ranges of approximately 300 miles on a regular basis?

A. Tropospheric scatter
B. D layer refraction
C. F2 layer refraction
D. Faraday rotation

T3C06

What mode is responsible for allowing over-the-horizon VHF and UHF communications to ranges of approximately 300 miles on a regular basis?

A. Tropospheric scatter

T3C12

Which of the following bands may provide long distance communications during the peak of the sunspot cycle?

A. Six or ten meters

B. 23 centimeters

C. 70 centimeters or 1.25 meters

D. All of these choices are correct

T3C12

Which of the following bands may provide long distance communications during the peak of the sunspot cycle?

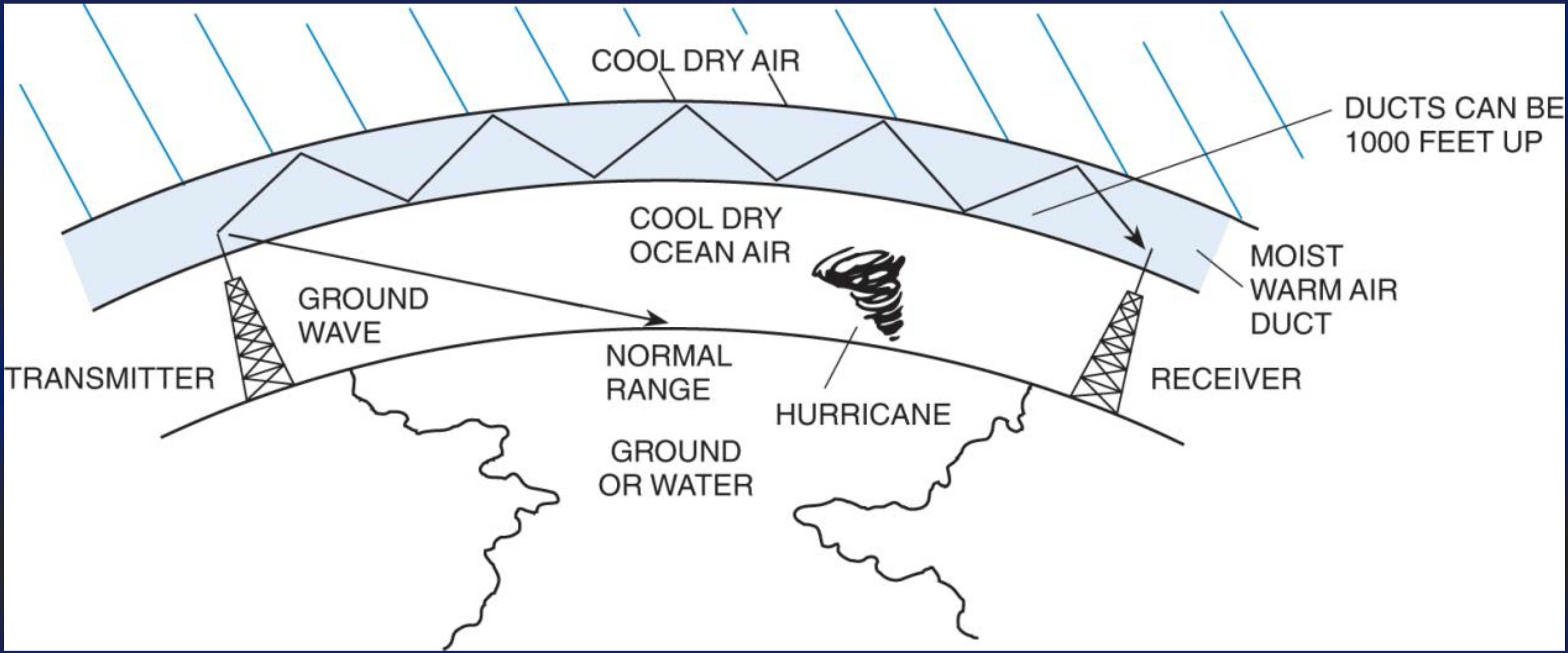
A. Six or ten meters

A really fun way to communicate is by using meteor scatter. Yes, hams not only bounce signals off the moon, but they also bounce signals off of meteor tails.

This is really fun, and action can be had almost anytime. Most meteor scatter takes place during the many meteor showers throughout the year, however.

The 6 meter band is best suited to communicating via meteor scatter. 2 meters is also used, but meteor scatter gets more difficult as one goes up in frequency.

A way to extend range on the 2 meter band is by using tropospheric ducting.



Temperature inversions in the atmosphere causes "tropospheric ducting".

T3C07

What band is best suited for communicating via meteor scatter?

A. 10 meters

B. 6 meters

C. 2 meters

D. 70 cm

T3C07

What band is best suited for communicating via meteor scatter?

B. 6 meters

T3C08

What causes tropospheric ducting?

A. Discharges of lightning during electrical storms

B. Sunspots and solar flares

C. Updrafts from hurricanes and tornadoes

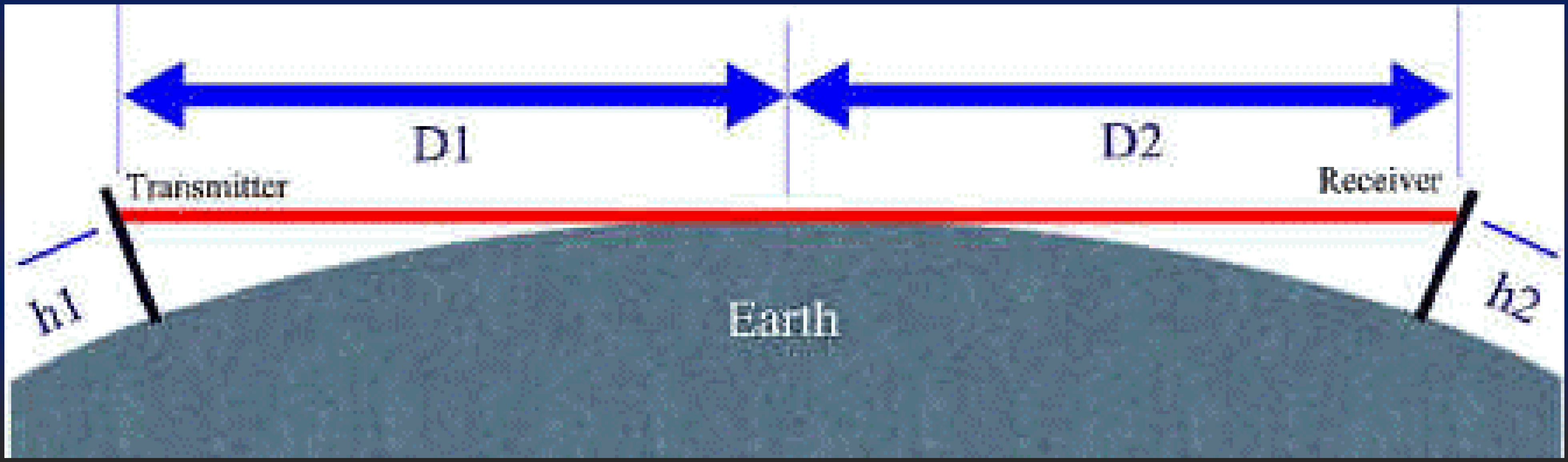
D. Temperature inversions in the atmosphere

T3C08
What causes tropospheric ducting?

D. Temperature inversions in the atmosphere

There are just a few more things you need to know about how radio waves travel.

The distance over which two stations can communicate by direct path is the radio horizon.



VHF and UHF signals are generally line of sight. So, obviously, the signals will go right out into space instead of curving around the planet.

There is an exception to this fact though:

VHF and UHF radio signals usually travel somewhat farther than the visual line of sight distance between two stations because the Earth seems less curved to radio waves than to light.

So, yes, VHF and UHF signals do go right out into space. It just takes them a bit longer than it does light.

T3C10

What is the radio horizon?

A. The distance over which two stations can communicate by direct path

B. The distance from the ground to a horizontally mounted antenna

C. The farthest point you can see when standing at the base of your antenna tower

D. The shortest distance between two points on the Earth's surface

T3C10

What is the radio horizon?

A. The distance over which two stations can communicate by direct path

T3C11

Why do VHF and UHF radio signals usually travel somewhat farther than the visual line of sight distance between two stations?

A. Radio signals move somewhat faster than the speed of light

B. Radio waves are not blocked by dust particles

C. The Earth seems less curved to radio waves than to light

D. Radio waves are blocked by dust particles

T3C11

Why do VHF and UHF radio signals usually travel somewhat farther than the visual line of sight distance between two stations?

C. The Earth seems less curved to radio waves than to light